Program for Warrior Injury Assessment Manikin (WIAMan)

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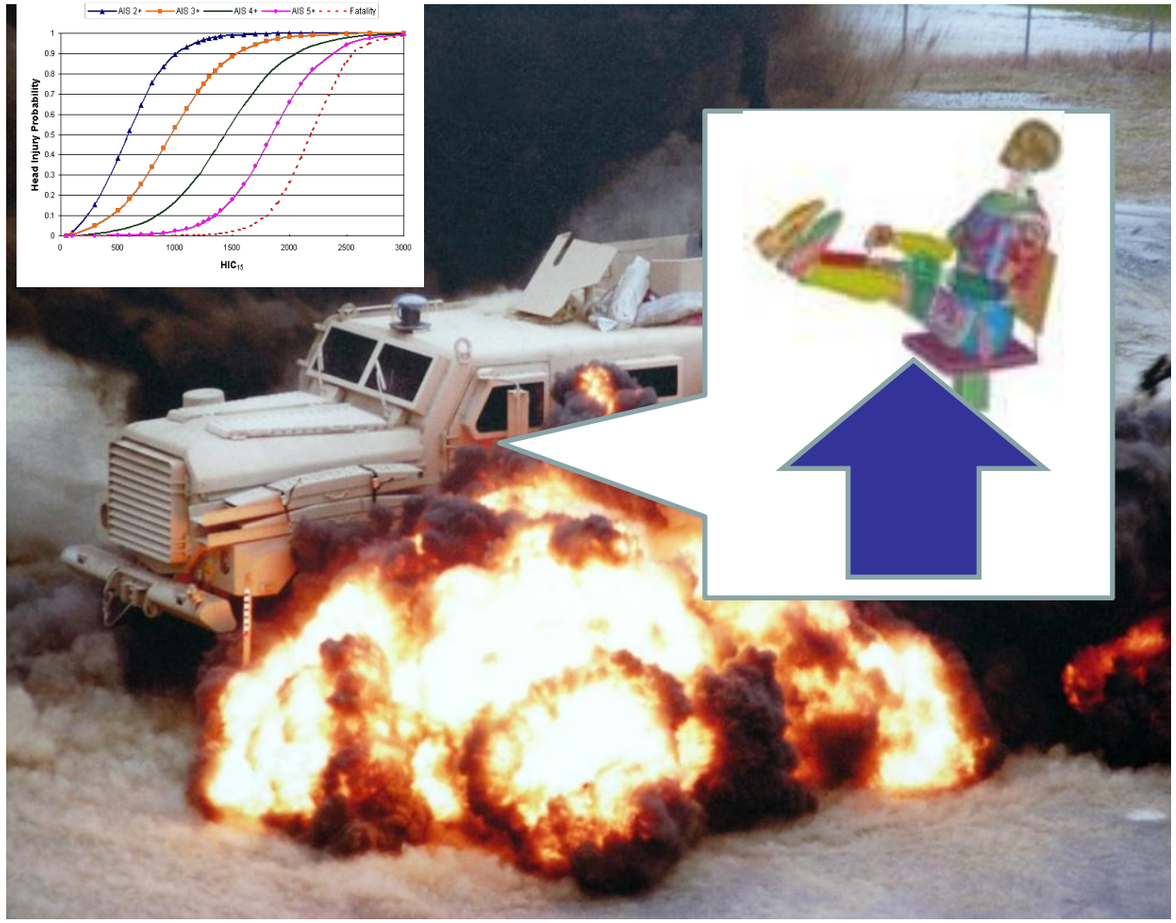
Warrior Injury Assessment Manikin & Framework



Purpose:

Create a Warrior-representative test dummy and associated biomedically-validated injury assessment tools for use in live-fire test & evaluation and vehicle development efforts

Results:

- A test dummy to provide an operationally relevant state of the art soldier surrogate
- Human response for individual body regions that inform the concurrent design of the test dummy
- A robust set of baseline data for blast events and resultant injuries
- Realistic accelerative injury response curves and analytical methods based on realistic vehicle environment in Under Body Blast testing
- Input to vehicle/weapon system designs to improve survivability

Schedule

MILESTONES	FY12	FY13	FY14	FY15	FY16	FY17
Define Warrior Environment						
Cadaveric Testing						
Injury Assessment Dev.						
Guidance to Stakeholders						
WIAMan Gen 1 Fab, & Test						
WIAMan Gen 2 Fab, & Test						

Milestone Indicators: TRL or SRL: ◆ Milestone Timeline: ▬

Payoff:

- Ability to accurately measure accelerative loads caused by Under Body Blast testing
- Increased knowledge of Warrior vulnerability in Under Body Blast testing
- State of the art criteria, methodologies & metrics used to assess injuries from accelerative loading sustained during Under Body Blast testing
- Potential for enhanced vehicle and soldier survivability

What is included the Plan?

- Types of Loading
  - Accelerative loading
  - Blunt impact
- Types of Injuries
  - Fractures
  - Dislocations
  - Amputations
  - Musculoskeletal injuries
- Direction(s) of interest
  - Primarily vertical
  - Multi-directional because off-axis exposures occur
- Leveraging of maturation of emerging injury criteria and surrogates
  - i.e., FOCUS & MIL-Lx
- Injury Research
  - Human tolerance & injury criteria research
  - Biofidelity/Biodynamics response/behavior research
  - IARV developments

What is not included?

- Types of loading
  - Primary blast
  - Ballistic penetration
  - Blunt impact due to ballistic events (behind armor effects)
- Types of Injuries
  - Research that would be based on cognitive measurements (TBI)
  - Internal organs
  - Acoustic trauma
  - Thermal/Inhalation
- Injury Research
  - Frangible/expendable surrogates/criteria
  - Stand-alone Modeling & Simulation efforts

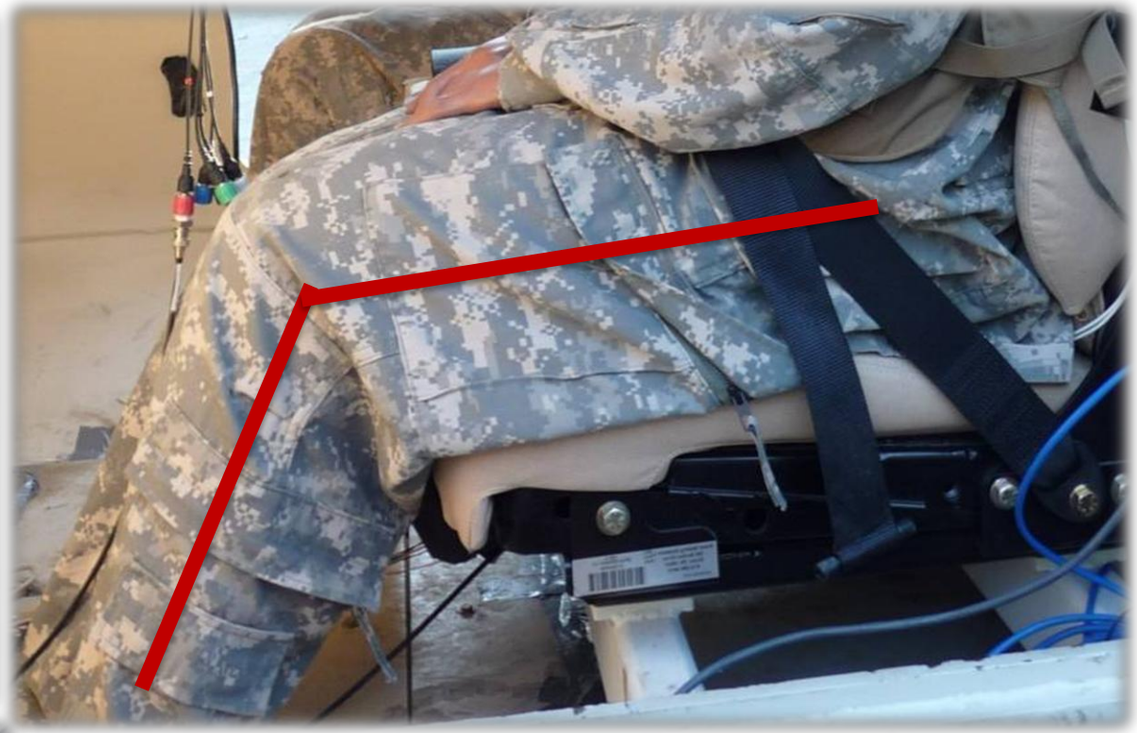
Occupant Loading Considerations

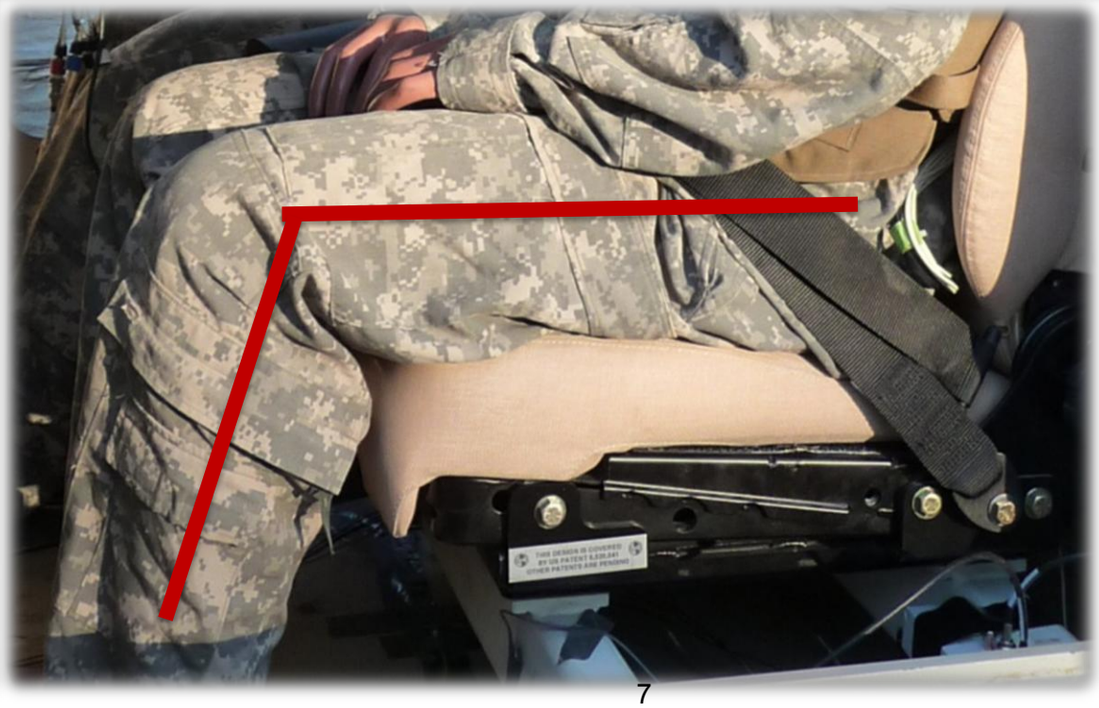
- Seat Mounting Variations
  - Stroking (Energy mitigating)
  - Floor
  - Wall
  - Ceiling

- Structural Variations
  - Energy mitigating flooring
  - Elevated foot rests (foot-pan, stirrups, etc)

- Occupant Operational Position
  - Drivers and Crew
  - Seating facing Anterior or Posterior
  - Seating facing Laterally towards vehicle center
  - Standing gunner
  - Variations in hip, knee, ankle angles
  - Operational preload

- Location of Blast Relative to Occupant
  - Creates numerous loading vectors





Technical Plan for Injury Assessment Research

Medical Research

For each body region:

Title: Biomedically valid injury risk curve development

What:
- Biodynamic Response Corridors
- Human Injury Probability Curves
- High Loading Rate Tissue Properties
- Injury Assessment Reference Curves

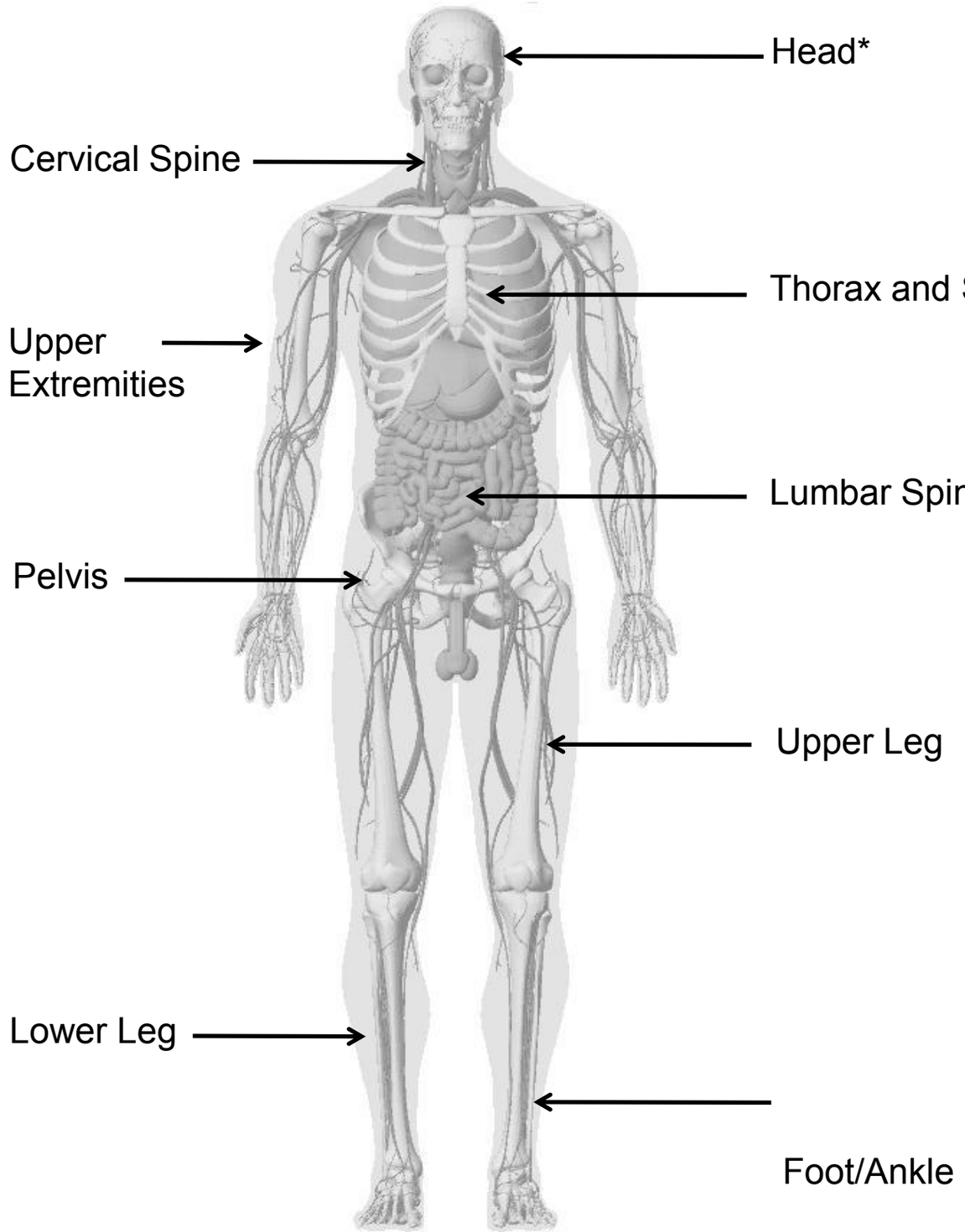
Why: Require biomechanical response corridors for surrogate development

Who: Laboratories with established cadaveric research programs with substantial government involvement (JAIWG)

When: Q3FY12 to Q2FY16

Where: Performing entity's laboratory

JAIWG PLAN (FALL 2010) FOCUSES ON 9 CORE BODY REGIONS WHILE ALLOWING FOR FLEXIBILITY OF EMERGING INJURY TRENDS



*Does not include mild traumatic brain injury

Program Execution Plan

Preliminary information necessary to conduct cadaveric testing by FY12

- Cataloging of operationally relevant injuries (JTAPIC)
- Existing LFT&E data mined to determine characteristic loading rate and direction range
- Analysis of occupant interaction with structure, seats, restraints, and PPE
- Analysis of probable occupant impact locations with free-flight equipment
- Determination of operational posture and what it means to occupant dynamics
- Anthropometry information be supplied by existing and ongoing soldier anthropometric studies

Incremental information made available to vehicle development programs throughout program

- New Injury Curves applied to existing Hybrid III in LFT&E if applicable
- Nominal occupant posture information
- Effect of anthropometry, occupant kinematics, and PPE

Peer-review by existing Injury Biomechanics and testing community

- Publication of non-sensitive results in open literature
- Technical Advisory Committee contains considerable Injury Biomechanics and LFT&E experience
- Documentation of results and findings available for government stakeholder review

Program Execution Plan

Based on validation of existing criteria for currently measured body regions

- Extensive historical data regarding measured loads in LFT&E
- Known areas of human tolerance information and anatomical familiarity by existing injury biomechanics community
- Current anatomical locations and injuries form strong basis for development of under-body blast specific methodology
- Mature and accepted test methodologies
- Low-risk development process

Cadaveric material property testing conducted by entities with extensive prior experience

- Existing Centers of Excellence in Injury Biomechanics limited almost exclusively to university labs
- Offers best collaborative possibilities with civilian world

Component and whole-body biofidelic verification completed primarily by government labs

- ATD development needs to be conducted in energetic environments to be successful
- Biofidelic testing requires a large number of tests; utilization of existing government assets reduces anticipated cost
- Provides easy transition to government test centers (ATC, RTC, etc.)

Program Execution Plan

Provides only ATD geometry and *initial* FEM to feed larger modeling and simulation efforts

- Injury prediction models *are not a prerequisite* of a validated ATD meeting all requirements of LFT&E
- A validated ATD *feeds* the development of future injury prediction model development

Timeline driven by cadaveric testing requirements

- Results sufficient to *begin* ATD material requirement development completed one year after cadaveric testing begins
- *Primary* loading path injury curves available to vehicle developers and LFT&E 18 months after cadaveric testing begins
- Duration of testing depends on the number of test parameters and the complexity of body region

Aggressive contractual requirements

What the government will provide

1a: Define the loading environment (displacement, acceleration, direction, etc.) which produces the injuries to be investigated

1b: Define the injury the ATD is intended to measure and the anticipated exposure loading conditions

2: Design and **test** - measure the applied loads and resultant injuries to produce **human injury tolerance curves** and **human response corridors** (*cadaver*)

3: Design and test - repeat exposures to **develop injury probability curves** (*cadaver*)

4: Develop mechanical surrogate to withstand anticipated loading conditions, measure the desired metric, and perform consistently and accurately (*ATD*)

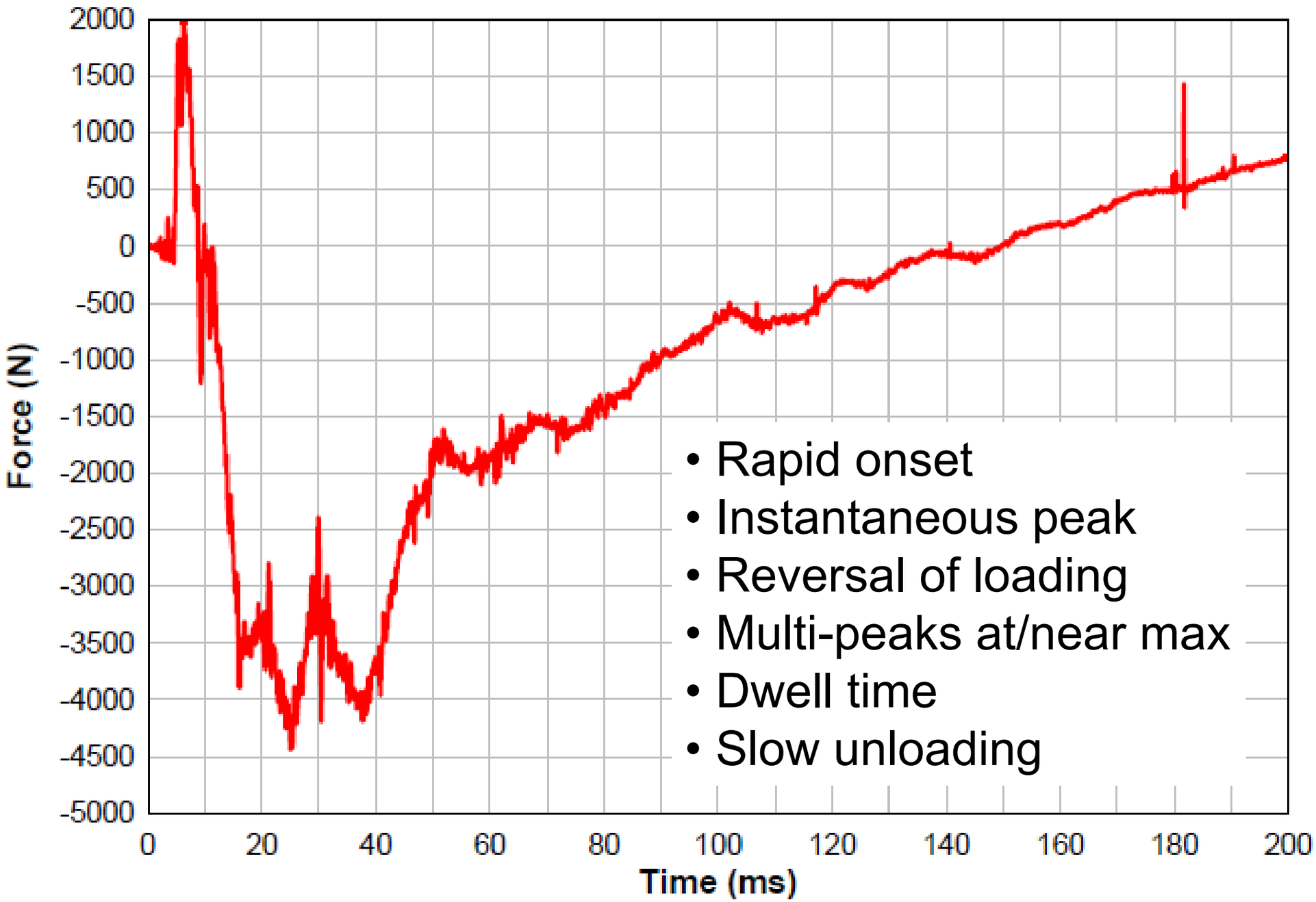
5: Matched-Pair Testing: Expose cadaver and ATD surrogate to *identical* loading conditions to correlate ATD response to human response
6: Establish IARVs (Injury Assessment Reference Values) and validate injury tolerance curves.

What the government will provide

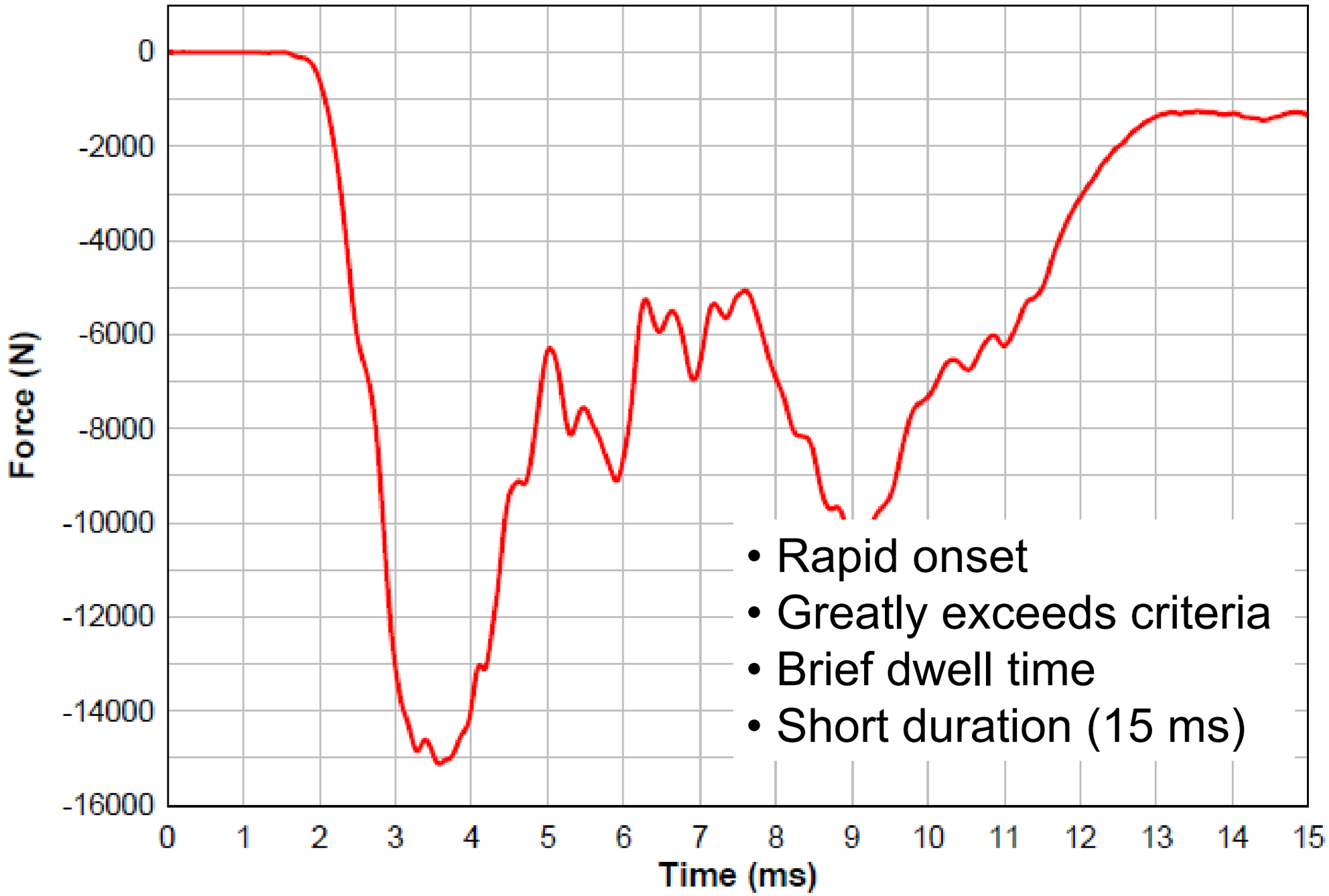
1a: Define the loading environment
(displacement, acceleration, direction, etc.)
which produces the injuries to be investigated

- Series of Generic Hull Tests
  - ATDs
  - PMHS
- Analysis of LFT&E Data
- Analysis of emerging data from theater and developmental testing

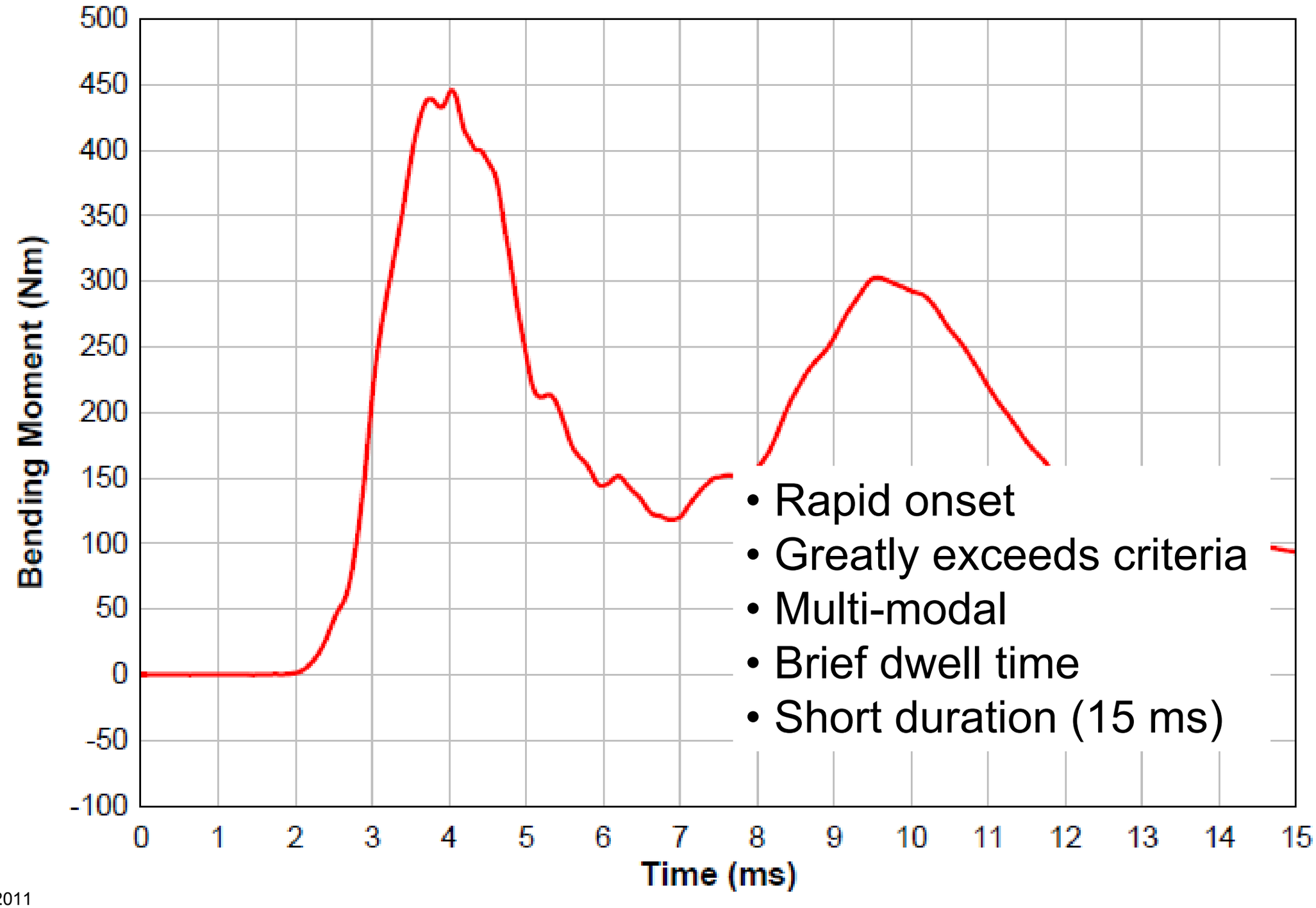
Lumbar Spine Compression



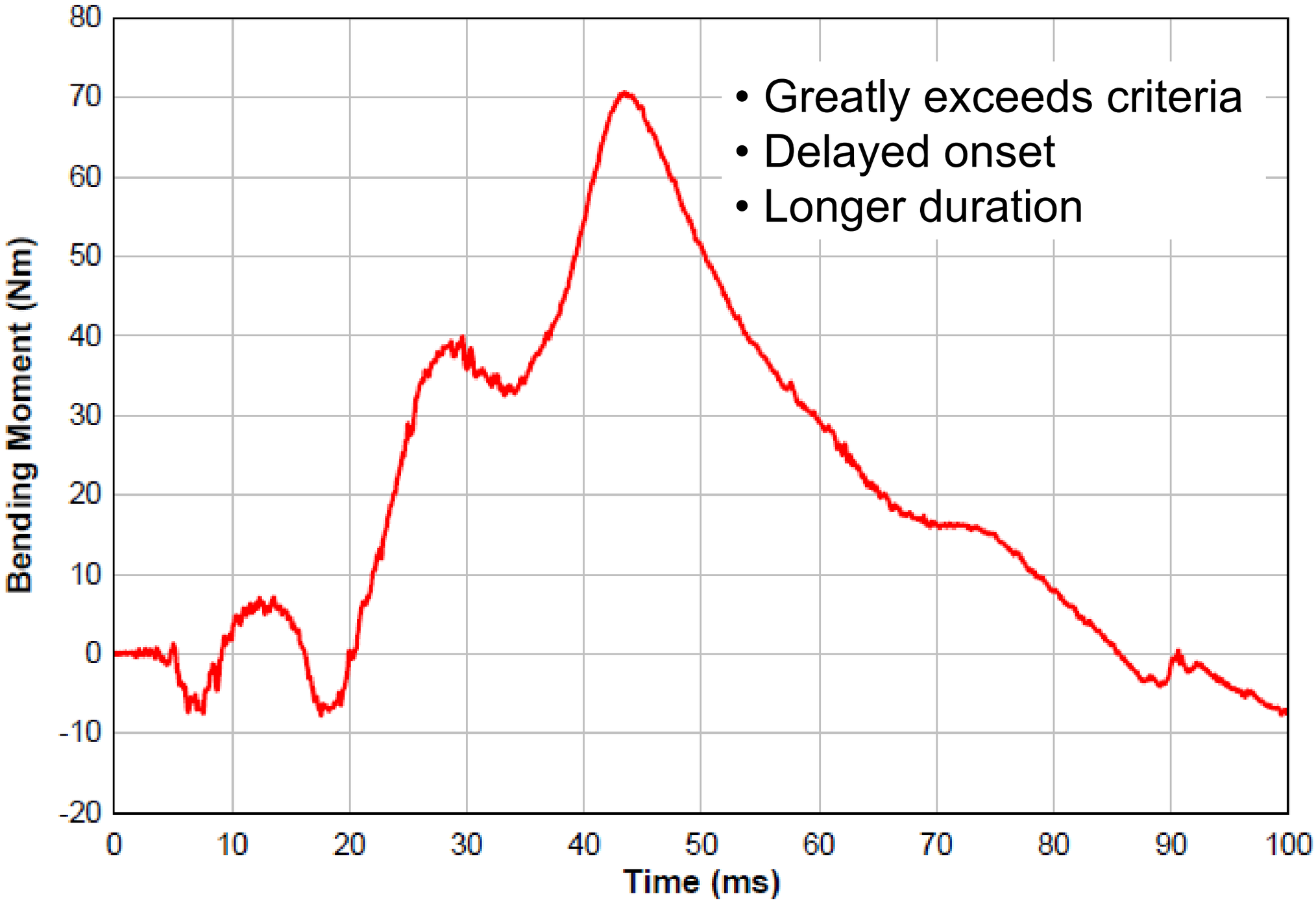
Right Lower Tibia Compression



Right Upper Tibia Bending



Upper Neck Extension



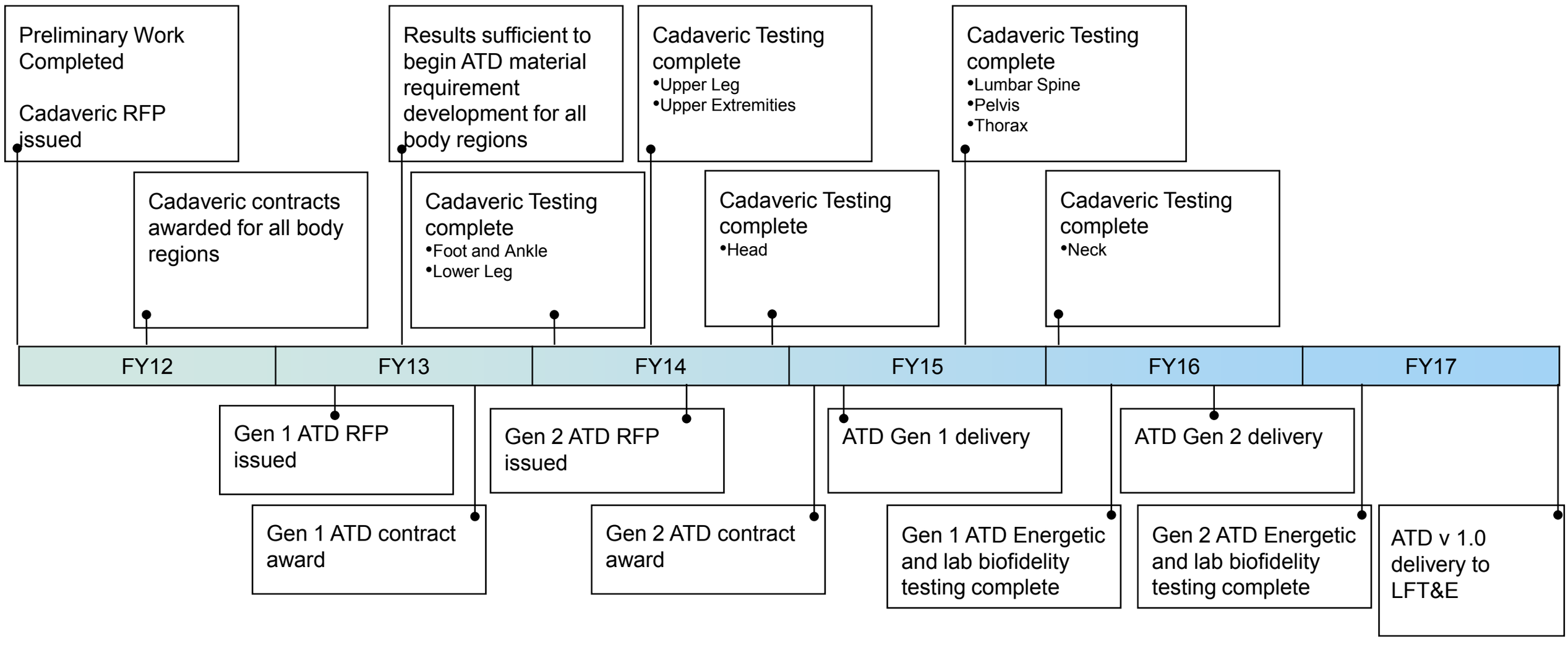
What the government will provide

1b: Define the injury the ATD is intended to measure and the anticipated exposure loading conditions

- Review of collected injury data
  - AIS
  - ICD-9
  - Medical Imaging
- Prioritize injuries to investigate with each body region

ATD Execution Plan

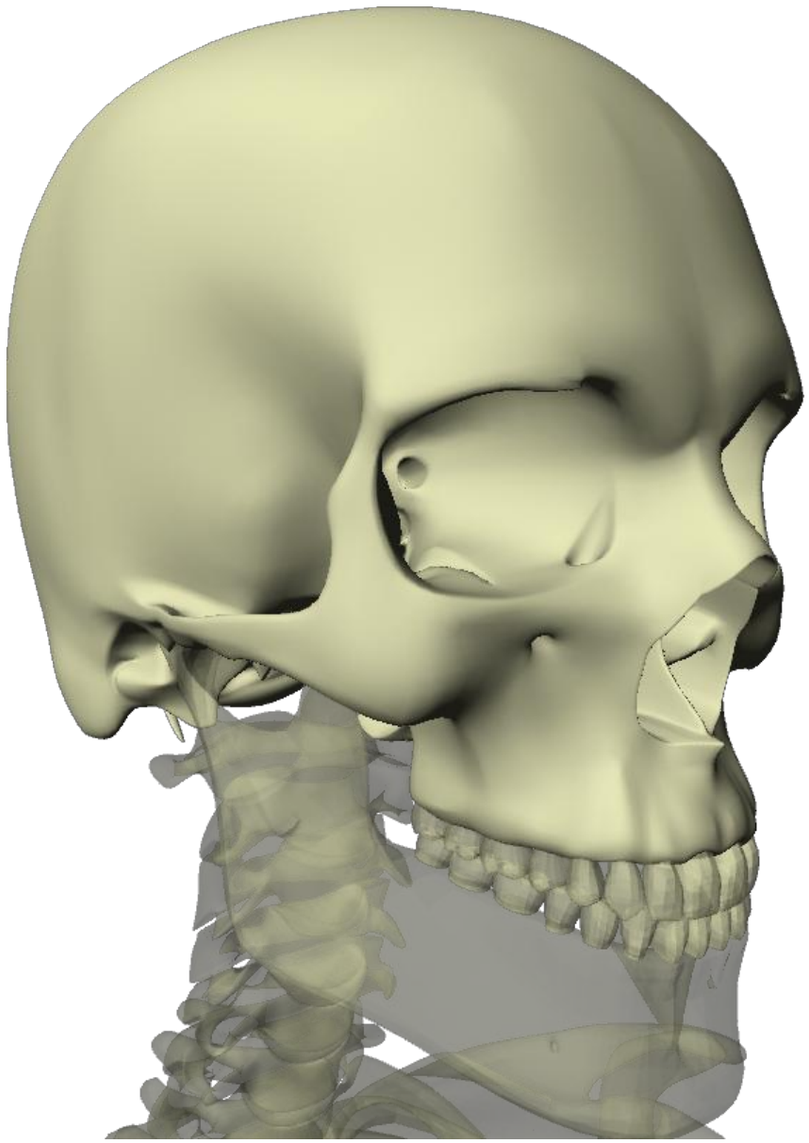
Medical and ATD Milestone Overview



Timeline driven by cadaveric testing requirements

ATD Development Plan

Head



Anticipated Enhancement:

- *Skull fracture* probability curves for (5) locations around crown for skull-helmet interaction for (3) loading rates
- *Skull fracture* probability curves for (3) lateral impact directions for skull-object interaction for (3) loading rates
- Maturation of FOCUS headform for injury curve development for blast-centric contact loading for facial fractures
- Investigative work for effects of angular rotation and linear acceleration effects on skeletal injuries

Target Initial Performance Period: 24 months

ATD Development Plan

Cervical Spine

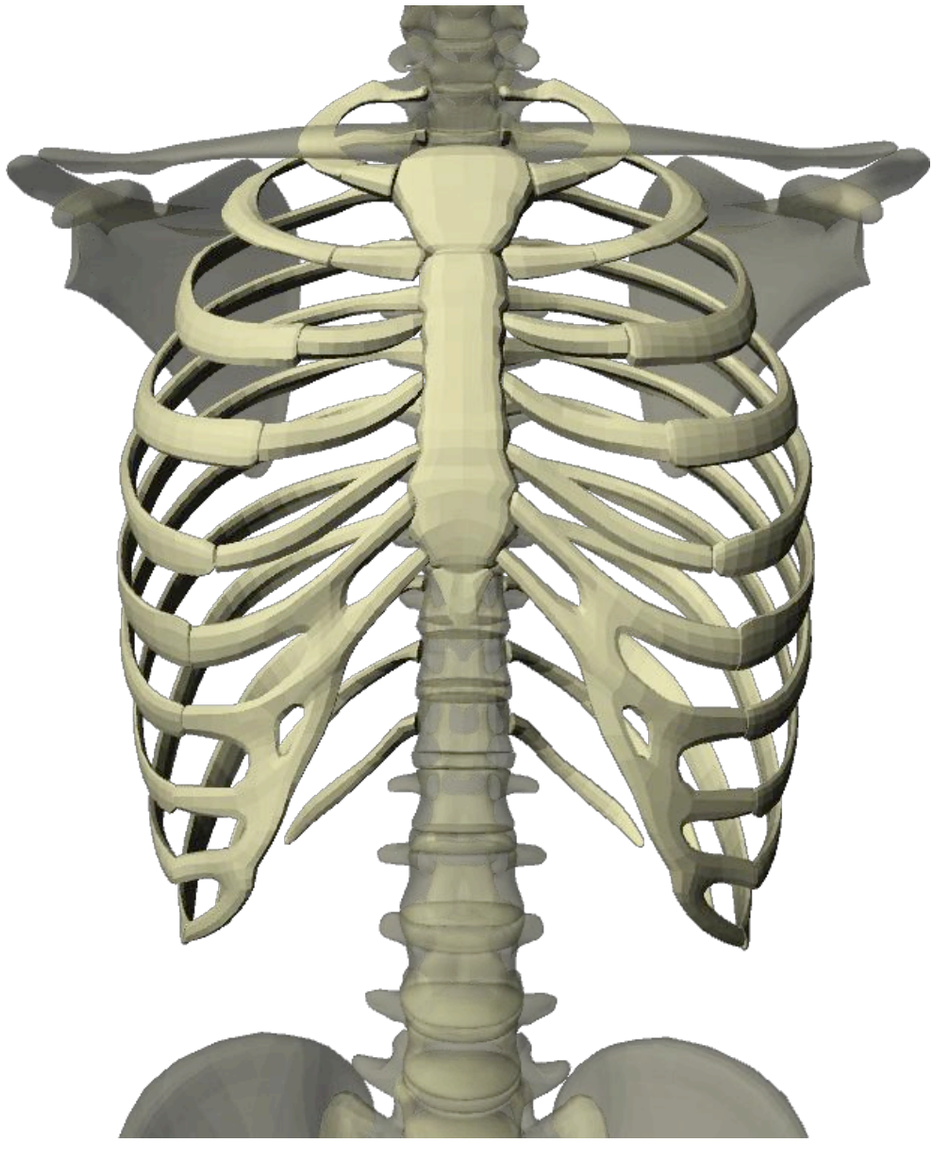
Anticipated Enhancement:

- Probability curves focused on *vertebral fracture, disc,* and *vertebral ligament damage* due to compression, tension, shear, flexion, extension, bending and *torsion.*
- Probability curves focused on acute spinal cord trauma
- Investigate effect of preloading due to head-supported mass

Target Initial Performance Period: 36 months

ATD Development Plan

Thorax and Shoulder



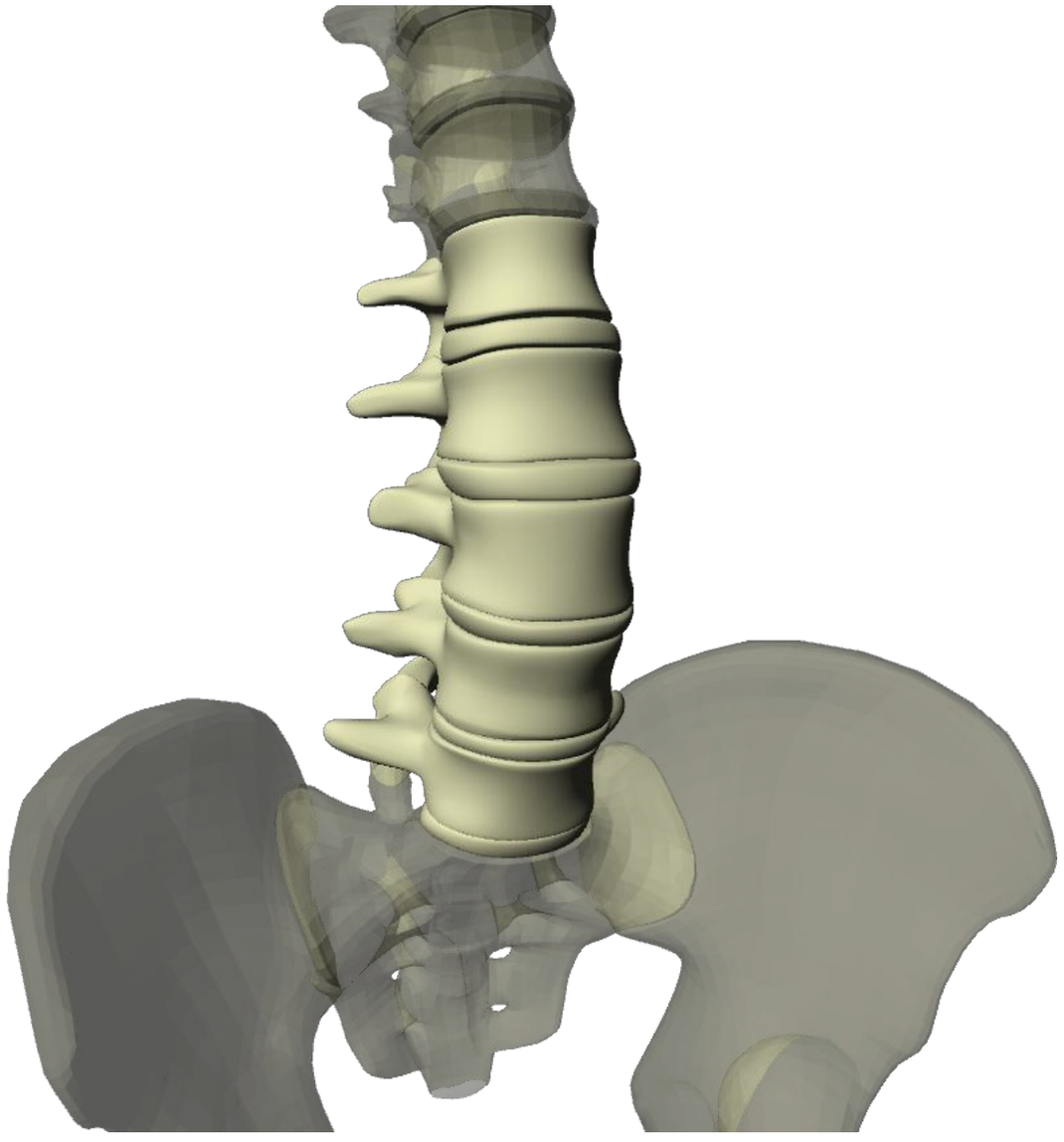
Anticipated Enhancement:

- Probability curves focused on *vertebral fracture, disc,* and *vertebral ligament damage.*
- Probability curves focused on *frame fracture* including rib fracture
- Probability curves focused on acute spinal cord trauma
- Investigate effect of preloading due to thoracic-supported mass
- Investigate thoracic response to 5 point restraint systems
- Volunteer study for shoulder rate-sensitive range-of-motion effects
- (All DoF) Primary and AP loading including 7, 9, and 11 o-clock oblique loading whole PMHS trunk testing

Target Initial Performance Period: 36 months

ATD Development Plan

Lumbar Spine



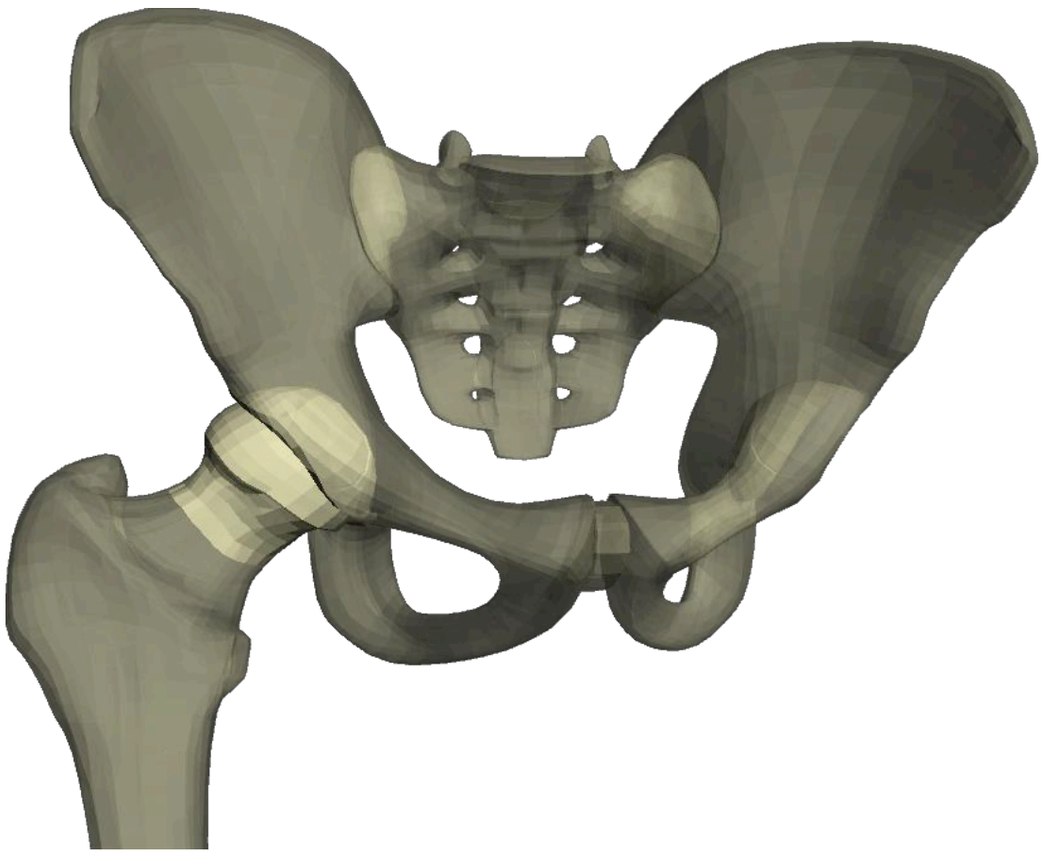
Anticipated Enhancement:

- Probability curves focused on *vertebral fracture, disc,* and *vertebral ligament damage* due to compression, tension, shear, flexion, extension, bending, and *torsion.*
- Probability curves for *combat burst fracture*
- Probability curves focused on acute spinal cord trauma
- Investigate effect of preloading (pre-compression and change in posture/orientation and torso stiffness) due to thoracic-supported mass

Target Initial Performance Period: 36 months

ATD Development Plan

Pelvis and Pelvis/Femur Interface



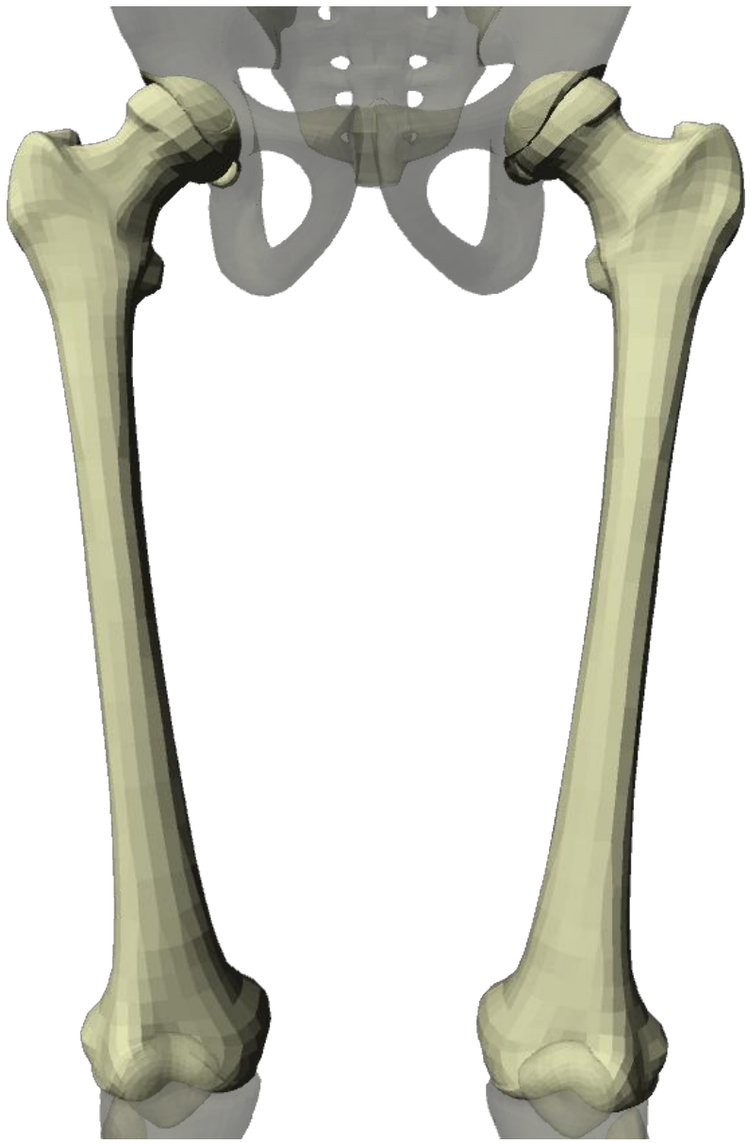
Anticipated Enhancement:

- Probability curves focused on *pelvic girdle fracture*
- Probability curves focused on *acetabular* injury
- Investigate effects of preloading due to thoracic-supported mass
- Investigate effects of PPE-thigh interaction on *acetabulum*
- (All DoF) Primary loading including effects of *hip orientation*

Target Initial Performance Period: 36 months

ATD Development Plan

Upper Leg



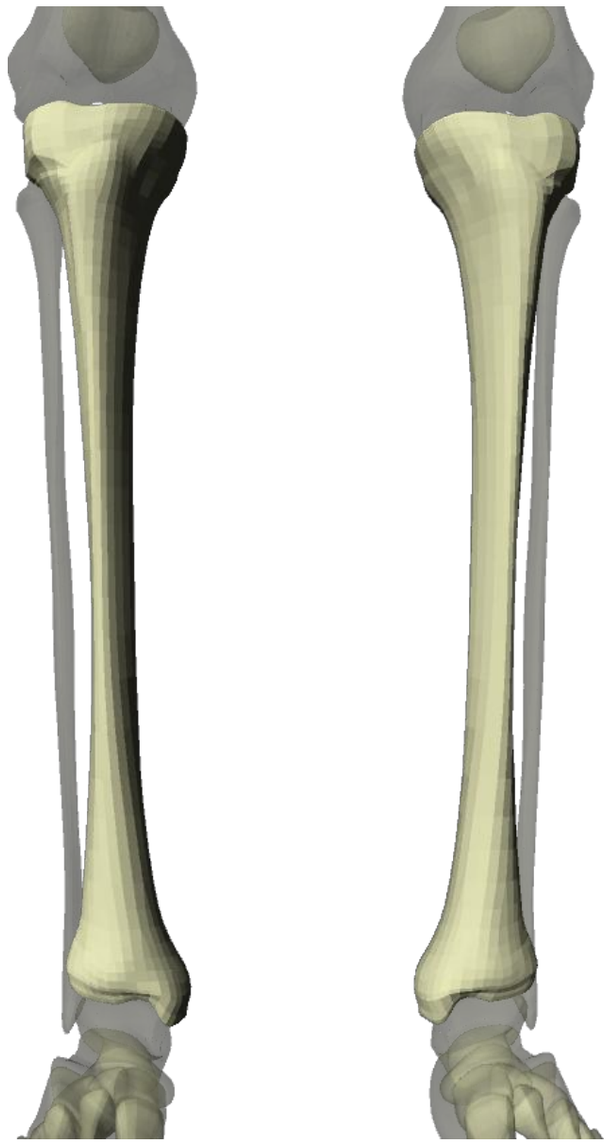
Anticipated Enhancement:

- Probability curves focused on high-rate *femoral shaft fracture* including tension
- Probability curves focused on high-rate *femoral head* fracture
- Combination metrics to include effect of combined bending and compression at high rate
- Investigate effects of PPE-thigh interaction on femoral shaft
- Investigate effects of knee angle (90 +/- 25 degrees) on loading
- Investigate effects of non-contact bending and shear through hip orientation (90 +/- 25 degrees)

Target Initial Performance Period: 24 months

ATD Development Plan

Lower Leg and Knee



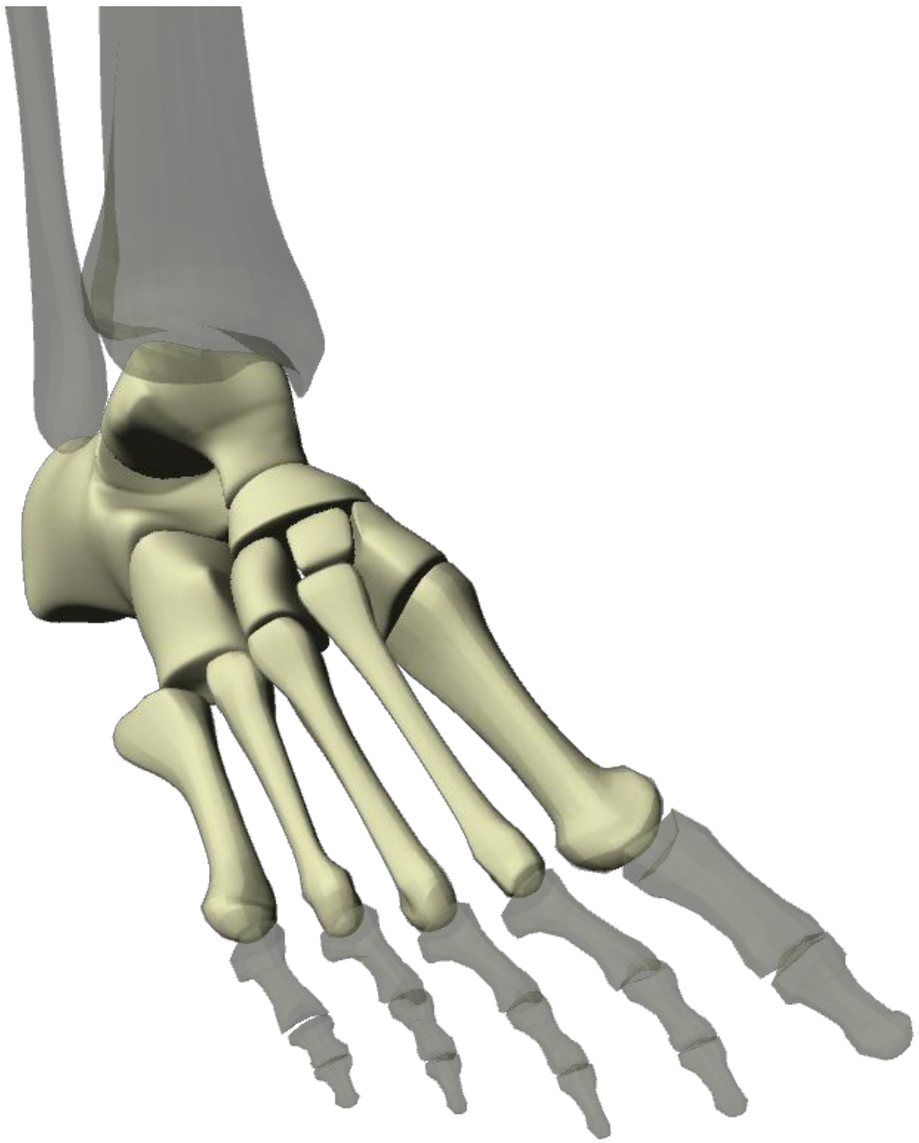
Anticipated Enhancement:

- Probability curves focused on high-rate *tibia shaft fracture*
- Probability curves focused on high-rate *condyle* and *patella* injury
- Probability curves for bending, shear, and torque at high rate
- Combination metrics to include effect of combined bending and compression at high rate
- Investigate effects of knee angle (90 +/- 25 degrees) on loading
- Maturation of existing MIL-LX leg development

Target Initial Performance Period: 18 months

ATD Development Plan

Foot and Ankle



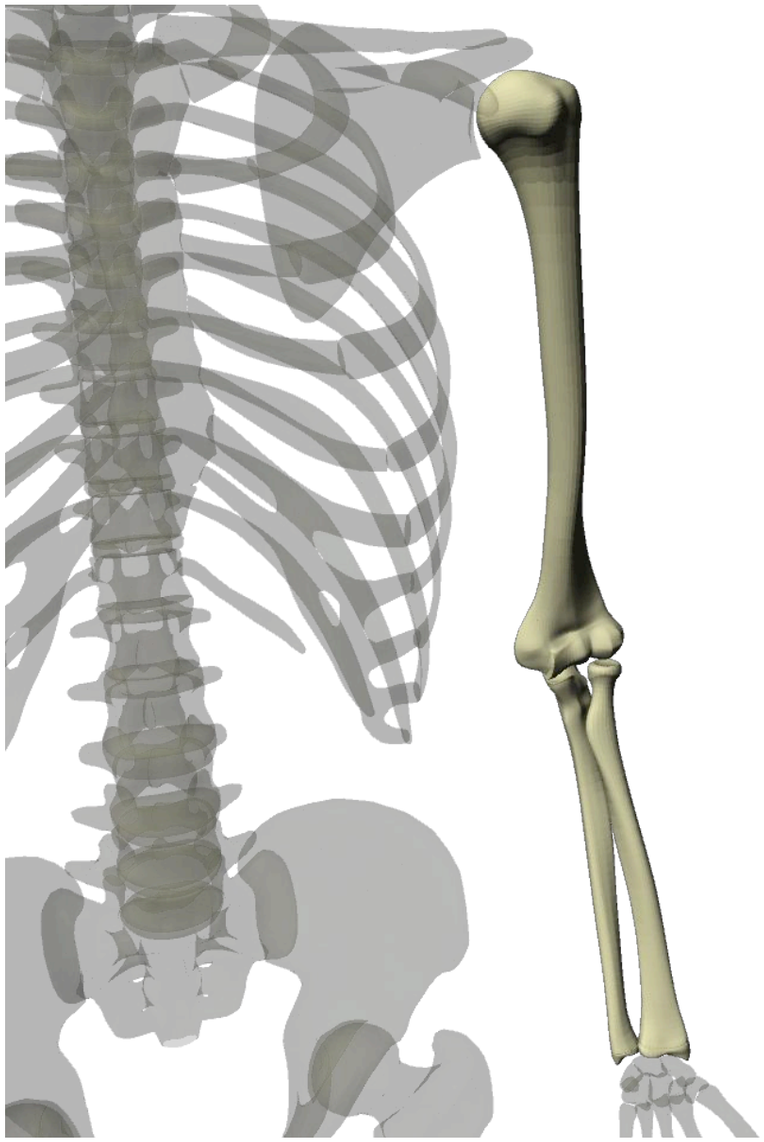
Anticipated Enhancement:

- Probability curves focused on high-rate *malleolus*, *talus*, and *calcaneus* fracture
- Probability curves for injury due to shear, and torque at high rate
- Investigate effects of ankle angle (90 +/- 25 degrees) on loading
- Maturation of existing MIL-LX leg development

Target Initial Performance Period: 18 months

ATD Development Plan

Upper Extremities



Anticipated Enhancement:

- Probability curves focused on *humerus, radius,* and *ulna* fracture due to *flail*
- Investigate effects of shoulder rotation on loading
- Investigate effects of elbow angle (90 +/- 25 degrees) on loading
- Investigate effects of PPE-thigh interaction on shoulder

Target Initial Performance Period: 18 months

Questions to Academia/Industry

- Will classification implications restrict your ability to execute?
- How can we best educate you on MRMC's PMHS and research policies?
- How open are you to multi-institutional collaboration?
- What else in addition to the data that we have discussed providing, would you need to perform research within this project?